



SECTION 204

EMBANKMENT CONTROL

SECTION 204.10 EMBANKMENT CONTROL STAKES

204.11 Description. This work shall consist of furnishing, setting and monitoring embankment control stakes for detection of earth movement.

204.12 Material. Embankment control stakes shall conform in type of material and dimensions to the requirements shown on the plans. The stakes and cross arms shall be painted white and the horizontal arm on each control stake shall have scale graduations in black for measuring movement.

204.13 Construction Requirements.

204.13.1 The stakes shall be set firmly in a vertical position by placing in predrilled holes and backfilling with a lean concrete mixture. Stakes shall be set at locations shown on the plans or as directed by the engineer and shall be set in straight lines or straight line segments. A straight line segment shall consist of not less than three vertical stakes aligned so as to form, with the horizontal cross arms, planes of visual reference for detection of earth movement. Cross arms need not be at constant elevation but shall be aligned along a constant line of sight plane. Adjacent or intersecting straight line segments may have common stakes.

204.13.2 Unless located on an embankment slope or berm, control stakes shall be placed prior to construction of the adjacent embankment except that, with the engineer's approval, embankment not to exceed 5 feet (1.5 m) high may be placed prior to installation of the stakes, if deemed necessary to minimize disturbance from equipment working in close proximity to the stakes.

204.13.3 It shall be the contractor's responsibility to maintain and protect the stakes from damage and to notify the engineer if movement is detected. Stakes damaged or misaligned by accident due to the contractor's negligence shall be replaced or realigned at the direction of the engineer, at the contractor's expense.

204.13.4 If movement is detected in the embankment control stakes, the engineer may require that embankment construction be discontinued for a period not to exceed 10 days until corrective measures can be determined.

204.14 Basis of Payment. Accepted embankment control stakes, complete in place, will be paid for at the contract unit price. No direct payment will be made for any devices required to protect the stakes nor for any delays resulting as a consequence of their use.

SECTION 204.20 SETTLEMENT GAUGES

204.21 Description. Settlement gauges shall consist of pipe gauges installed for the purpose of obtaining foundation settlement data during the placing, and following completion, of embankment and surcharge construction. An estimated number of settlement gauges will be

indicated in the contract; however, the exact number and location will be determined by the engineer.

204.22 Material. A settlement gauge shall consist of the following:

(a) A steel plate, with a galvanized riser pipe attached perpendicular to the plate at its center by a continuous weld.

(b) Lengths, to be approved by the engineer, of 3/4-inch (19 mm) threaded galvanized riser pipe and couplings.

(c) Lengths, to be approved by the engineer, of galvanized 1 1/2-inch (38 mm) threaded pipe and couplings to act as a cover or guard for the riser pipe.

204.23 Construction Requirements.

204.23.1 The first section of the 3/4-inch (19 mm) pipe shall be welded to the plate. The distance from the top of plate to the top of pipe will be accurately measured and recorded by the engineer.

204.23.2 An excavation, slightly larger than the plate, shall be made to a depth approximately 18 inches (450 mm) below the natural ground surface. Care shall be exercised during excavation to ensure that the bottom of the pit is level and that the material at this location is undisturbed. The pit bottom shall be covered with a layer of portland cement mortar, approximately 3 inches (75 mm) thick, and the plate bedded therein in such position that the riser pipe is vertical. After the mortar has set, the cover pipe, cut approximately 6 inches (150 mm) shorter, shall be slipped over and centered around the riser pipe. The backfill shall then be placed in 6-inch (150 mm) layers and thoroughly compacted. The contractor shall notify the engineer when the installation is complete. No embankment shall be placed around the gauge until the elevation of the top of the riser has been determined by the engineer.

204.23.3 Embankment material in the immediate vicinity of the settlement gauge pipe shall be placed and compacted in accordance with the requirements of [Sec 726.6.1](#). When the elevation of the embankment reaches a level approximately one foot (300 mm) below the top of the cover pipe, the engineer shall be notified and the next section of riser pipe and cover pipe shall be installed in the engineer's presence. As the height of the embankment increases, this procedure shall be repeated until the embankment and surcharge is completed, and the pipe sections, both riser and cover, extend approximately 2 feet (600 mm) above the surface of the completed embankment and surcharge.

204.23.4 All necessary precautions shall be taken to keep the alignment of the riser pipe and cover pipe maintained in a vertical position at all times. The contractor shall operate equipment so that the settlement gauges are not damaged or displaced. Protective barriers shall be erected when so directed by the engineer. Settlement gauges shall be maintained in a satisfactory operating condition until after placing of the embankment and surcharge and until, in the judgment of the engineer, the settlement readings are no longer necessary. Any gauges that are damaged shall be repaired or replaced by and at the contractor's expense.

204.23.5 The engineer will obtain and record all measurements and elevations necessary for accurate determination of settlement data during and after completion of embankment and surcharge.

204.24 Basis of Payment. Accepted settlement gauges, complete in place, will be paid for at the contract unit price. No direct payment will be made for any devices required to protect the gauges.

SECTION 204.30 PORE PRESSURE MEASUREMENT DEVICES

204.31 Description. This work shall consist of placing and maintaining pore pressure measurement devices as shown on the plans for obtaining foundation pore pressure measurements during the placement of embankment. Pore pressure measurement devices, locations, elevations and limits of embankment subject to control by each device will be shown on the plans.

204.32 Equipment. Pore pressure measuring devices shall consist of the following types:

(a) Type A. This device consists of a pneumatic transducer sealed within a sand chamber which is set into the foundation to the specified elevations. The transducer is attached to jacketed plastic tubing which extends to the surface for connection to pressurizing and gauging equipment.

(b) Type B. This device consists of a 1/2-inch (13 mm) PVC standpipe extending to the surface of the embankment from a sand chamber set into the foundation to the specified elevations.

204.32.1 The pneumatic transducer, jacketed tubing, and necessary pressurizing and gauging equipment for Type A installations will be furnished by the Commission without cost to the contractor upon two weeks written notice preceding the date of installation. The balance of the material for the Type A installation shall be furnished by the contractor. All material for the Type B installation shall be furnished by the contractor, except an electrical sounding device.

204.33 Construction Requirements.

204.33.1 The contractor shall be responsible for making the installation, for furnishing all incidental material, for providing all necessary protection of the installation, and for replacement in the event of damage, including cost of any replacement equipment furnished by the Commission. In the event of damage to the installation, the engineer may require suspension of embankment construction in the controlled area until the contractor has restored the installation to satisfactory working order. Installation of the pore pressure measurement device shall precede placement of any embankment by at least two weeks to allow time for testing of the completed installation and replacement in the event of malfunction. No embankment may be placed until the installation is complete and tested to the satisfaction of the engineer.

204.33.2 A hole of not less than 5 inches (125 mm), nor more than 8 inches (200 mm) in diameter, shall be drilled to elevation B as defined in the plans. If necessary, casing shall be used to prevent sloughing of material from the walls of the hole and contamination of the walls or bottom of the hole by sloughed material. Casing shall be no smaller in its outer diameter than the diameter of the hole and shall have no externally coupled joints in the bottom 10 feet (3 m).

204.33.3 If casing is required, the hole shall be washed to the bottom with clean water circulated through the bit until the discharge is clear. Clean sand shall then be poured into the hole to the approximate depth shown on the plans. The assembled pore pressure measurement device shall then be lowered to its indicated position with care to avoid contamination with soil from the side of the hole and additional sand shall be placed around it to elevation A as shown on the plans. During these steps, any casing shall be pulled ahead of the backfill in increments of 6 inches to 24 inches (150 to 600 mm) as necessary to prevent collapse or sloughing of the hole. The hole shall be maintained full of clean water during these steps to at

least the elevation of the top of the sand chamber. Every effort shall be made to prevent the creation of pockets of soil, air or voids in the sand backfill.

204.33.4 After sand is placed to the specified elevation, the hole shall be backfilled with wetted, plastic bentonite clay as the casing is withdrawn, for not less than 4 feet (1.2 m) above the top of the sand filled chamber. If necessary, the clay shall be worked by hand into plastic balls to be dropped into the hole and tamped into a coherent mass. An acceptable alternate is the use of preformed dry bentonite pellets. In dry installation, dry granular bentonite may be tamped in place. The remainder of the hole shall be filled with a thick slurry of bentonite.

204.33.5 At natural ground level, or as otherwise directed by the engineer, four layers of 3/4-inch (19 mm) exterior grade plywood, 4 x 4 feet (1200 x 1200 mm), nailed and clinched together with rustproof nails, and with a 3-inch (75 mm) diameter hole cut at the center shall be centered over the installation after the ground is smoothed and leveled with sand. A closet flange or other suitable receptacle shall be securely fastened to the plywood over the 3-inch (75 mm) diameter hole so as to securely receive a 5-foot (1.5 m) length of 3-inch (75 mm) iron or steel casing. Earth or sand shall be compacted about the casing in 6-inch (150 mm) lifts with care to avoid misalignment after the engineer has established the elevation of the plywood slab and the top of the casing.

204.33.6 Upon completion, each installation shall be tested. Type A installations shall be tested in accordance with recommendations of the transducer manufacturer. Type B installations shall be tested by dropping a weighted line through the standpipe to check for possible obstructions. The standpipe shall then be filled with water and periodic readings made of the water level in the standpipe until the level of natural ground water is reached. If less than a 70 percent drop in head is experienced in the first 24 hours, the standpipe shall be flushed and retested. Records of rate of head loss shall be kept for subsequent evaluation of possible time lags in response of water levels to embankment placement.

204.33.7 The engineer may require the installation of additional pore pressure measurement devices, at the contract unit price, within any area subject to control by such devices, at any time during the construction of the embankment. The engineer will determine the type of device, location and elevation of additional installations. Any such additional pore pressure measurement devices shall govern the rate of construction in the same manner as the original devices. The reference pressure levels for additional devices shall be either that of the original devices or as determined from boreholes located outside the loaded area, as directed by the engineer.

204.34 Pore Pressure Measurements and Records.

204.34.1 The engineer will make and record all observations and measurements required to determine natural ground water pressures and pore water pressures induced by embankment construction. The pressure of the natural ground water existing at the time of installation and prior to placement of any embankment will be used as a reference to determine pore pressures induced by subsequent embankment placement. However, the engineer may subsequently require borings outside the loaded area to facilitate observations to determine if the natural ground water table has lowered due to seasonal or climatic variations. Such observations may be used to lower, but not raise, the initial reference ground water pressure.

204.34.2 The engineer will make all records of ground water and pore water pressures readily available to the contractor for guidance in the planning of the contractor's work.

204.34.3 If foundation pore pressure, in excess of pressure from the natural water table, equals or exceeds 35 percent of the unit pressure of the embankment in place over the installation at any time, placement of embankment shall be immediately suspended.

Construction shall not resume until such excess pressure declines to 25 percent of embankment pressure, unless otherwise authorized by the engineer.

204.34.4 After the embankment reaches an elevation equal to 60 percent of the maximum height, the contractor shall control the rate of construction in such a manner that foundation pore pressure, in excess of pressure from the natural water table, will not exceed 35 percent of the unit pressure of the embankment in place over the installation at any time. [An example of pressure relationships follows: Soil embankment with an average wet density of 125 pounds per cubic foot (2000 kg/m^3) is equal to twice the unit weight (mass) of water. A foot (0.3 meter) of such embankment thus has a potential to create, at most, 2 feet (0.6 meter) of water rise in a standpipe, or a 0.87 pound per square inch (5.9 kPA) increase in a Type A installation. The contractor may thus anticipate the maximum possible effect of any load to be added.] The contractor is cautioned that Type B installations are prone to some time lag in rate of response to a pressure increment. Records of pore pressure response during placement of the first 60 percent of embankment height shall be examined for evidence of such lag. The time required for dissipation of head during testing will also be indicative of the rate of response.

204.34.5 When embankment has advanced to within approximately one foot (300 mm) of the top of the casing, the casing and the 1/2-inch (13 mm) PVC pipe for the Type B installations, shall be advanced in 5-foot (1.5 m) increments. No extension shall be made without the engineer's approval. PVC pipe extensions shall be made using solvent welded couplings exercising care to make smooth, squared cuts with all burrs removed, in accordance with recommendations of the pipe and solvent cement manufacturers. Pneumatic tubing leads used with Type A installations shall be long enough to permit extension, without connections, to the top of the embankment or surcharge. Excess tubing shall be stored in a steel container attached to the last casing extension as shown on the plans.

204.35 Settlement Records. The engineer will make and record all measurements and elevations necessary, including elevations of the plywood plate and all casing extensions, for use in establishing a settlement record at the site of the pore pressure measurement device. The 3-inch (75 mm) outer steel casing will be used for this purpose. Care shall be taken to ensure the tightest possible coupling connections, using pipe wrenches, without rotating the bottom pipe. Settlement records obtained in this manner may be used to satisfy such settlement rate requirements as may be outlined in the contract.

204.36 Basis of Payment.

204.36.1 The contract unit price shall include acceptance by the contractor of the possible restraints inherent in the use of these devices upon the rate of construction. No additional compensation will be made for any costs incurred as a result of compliance with this requirement.

204.36.2 Accepted pore pressure measurement devices, complete in place, will be paid for at the contract unit price per each.